

Flooding requirements for biodiversity values along the Victorian floodplain of the Murray Valley

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Abstract

Overbank flooding of rivers is a key process in the maintenance of vegetation types and the species that rely on the floodplain forests and woodlands of northern Victoria. Yet the flooding requirements of species and vegetation types are poorly known. Here we present initial estimates of the water requirements for flood-dependent Ecological Vegetation Classes (EVCs) and rare and threatened flora and fauna species associated with the floodplain of the Murray River and its tributaries. Some 110 EVCs were found to be at least partly flood-dependent on the Murray River floodplains. The total current extent of these EVCs in the study area is 224 247 ha, of which 162 266 ha are on public land. One hundred and twenty-four rare or threatened plant taxa and 62 threatened vertebrate fauna taxa (excluding fish) were classified as at least partly flood-dependent. These initial estimates provide important information for land and water managers and researchers alike. (*The Victorian Naturalist* 128 (2), 2011, 48–85)

Keywords: River Red Gum forests, flood requirements, ecological vegetation classes, threatened species, environmental watering

Introduction

The floodplain forests, woodlands and wetlands of the Murray River and its tributaries contain important and unique species of flora and fauna and extend the geographic range of a number of species, particularly birds, into the semi-arid regions of the Riverina and Mallee (e.g. Tzaros 2001). Pulsed flooding is the major factor influencing biota in these river-floodplain systems (Ballinger and Mac Nally 2006). These overbank floods also maintain ecological connectivity along the length of the floodplains, across the floodplains and between the rivers and the floodplains, thereby playing a crucial role in the landscape ecology of the region (Ballinger and Mac Nally 2006).

However, there has been no comprehensive inventory of important natural values or flooding requirements to maintain these values along the Murray River floodplains. This is true

for both the vegetation types and the species that rely on them. This information is vital if informed management of environmental flows is to be undertaken.

In this paper we present for the first time initial estimates of the flood requirements for a comprehensive suite of Ecological Vegetation Classes and rare and threatened flora and fauna species within the Murray Valley. The natural values and their flooding requirements were identified as part of final recommendations of the Victorian Environmental Assessment Council's (VEAC's) investigation of River Red Gum Forests in northern Victoria (VEAC 2008). Identification and mapping of these values allows environmental and water managers to make more informed decisions about which flood-dependent natural values receive and miss out on environmental water (Peake *et al.*

2011). This is particularly pertinent considering the planning by the Murray–Darling Basin Authority (MDBA) for the development of a basin-wide plan which incorporates environmental watering (e.g. MDBA 2010), and the need for adaptive conservation strategies for freshwater ecosystems in the face of climate change (Aldous *et al.* 2011). Our study complements recent analysis that outlines tolerable fire intervals for Victorian vegetation types (Cheal 2010). This article serves as a companion paper to another (Peake *et al.* 2011) which describes how this information can be used to display spatially the values and their flooding requirements.¹

Methods

Study area

The VEAC River Red Gum Forests investigation area encompassed some 1 220 000 ha of northern Victoria from the South Australian border east to the wall of the Hume Dam near

Wodonga. It included the floodplain ecosystems along the Murray River and seven of its major tributaries (the Avoca, Loddon, Campaspe, Goulburn, Ovens, King and Kiewa Rivers) as well as grassy ecosystems and wetlands of the Victorian Riverina – for further details see Fitzsimons (2006) and VEAC (2006) (Fig. 1). The present study covered only the floodplains of the Murray, Goulburn, Ovens and King Rivers within the VEAC investigation area – a study area of approximately 507 000 ha, collectively referred to here as the Murray River floodplain (Fig 1.). Time did not permit coverage of the Kerang Lakes and floodplains of the Avoca, Loddon, Campaspe and Kiewa Rivers nor any part of New South Wales or South Australia.

Identifying flood requirements — Ecological Vegetation Classes

EVCs are units in a vegetation classification system that are differentiated through a combination of floristic, life form and ecological

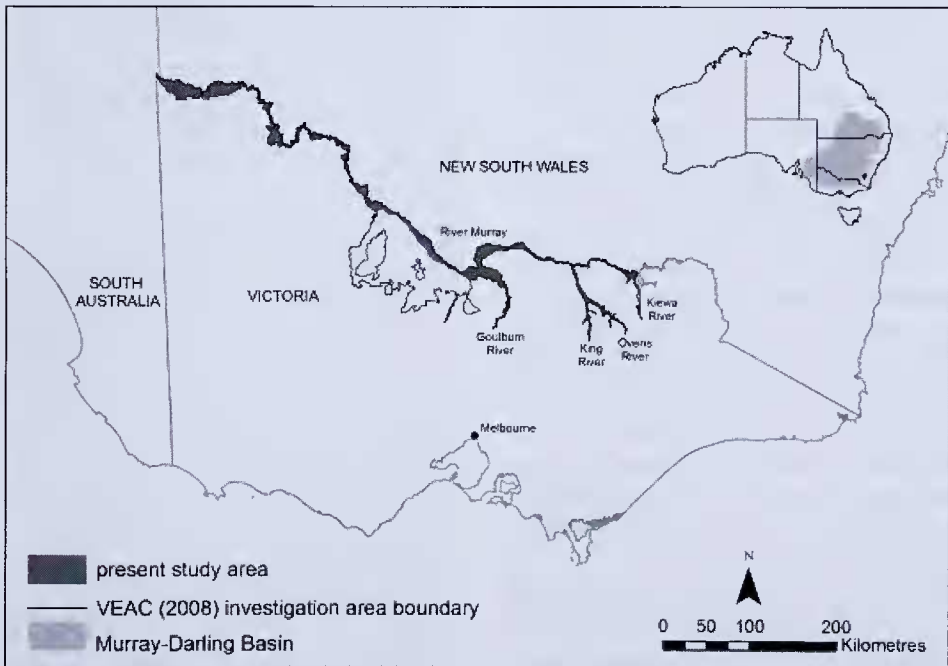


Fig. 1. Location of VEAC River Red Gum Forests Investigation area and floodplain values mapped in this analysis.

characteristics, and through an inferred fidelity to particular environmental attributes. They are the principal units for native vegetation classification and mapping for land-use planning and management in Victoria (e.g. Woodgate *et al.* 1996; Parkes *et al.* 2003).

The EVC dataset used in this study is the publicly accessible geospatial vector layer maintained by the Victorian Department of Sustainability and Environment (DSE) (current at January 2008). It describes the EVCs in terms of their structure, composition and environmental context. For the Murray River floodplains this has been mapped at a scale of 1:25 000. In our assessment, we built on this dataset by identifying the flooding requirements for each flood-dependent EVC, based on the life-history traits, tolerances and competitive advantages of the dominant and characteristic plant taxa. This new information was appended to existing EVC polygons. As few of the plant species have been the subject of detailed autoecological studies, estimates of flooding regime variables are based on the expert opinion of DF and MW, who were closely involved in the circumscription and mapping of EVCs in 2006, and searches of the available literature.

The process entailed four steps, as follows:

1. *Identification of flood-dependent EVCs.* EVCs were classed as flood-dependent if likely to decline significantly in condition (*sensu* Parkes *et al.* 2003) in the region in the absence of overbank flows from adjoining rivers (as opposed to flooding or watering solely from local rainfall). As such, overbank flooding is integral to key ecological processes for many EVCs, or structurally important constituents of the vegetation such as regeneration, dispersal and growth. Ecological dependence on flooding extends beyond merely meeting watering requirements of the plants and animals and includes important geomorphological processes such as the deposition of silts, and the regulation of ground water depth and chemistry. For details on the ecological characteristics of the main EVCs in the VEAC investigation area see Appendix 7 of VEAC (2006).
2. *Estimation of the 'natural flood frequency' for flood-dependent EVCs.* The natural flood frequency is the average frequency with which

an EVC is flooded under natural conditions and is therefore, presumably, the optimal frequency of inundation for that EVC. Sustained deviation from the natural flood frequency is assumed to compromise EVC condition. In the absence of long-term historical information for the EVCs, the natural flood frequency for each flood-dependent EVC was estimated based on what is known or surmised by our expert assessors of the flooding requirements and tolerances of character species and the physical (including hydrological) conditions at sites of occurrence, particularly in comparison to these parameters for adjoining or similar EVCs.

3. *Estimation of the 'critical interval' for flood-dependent EVCs.* The critical interval is the maximum period that an EVC can endure without flooding and remain capable of returning to its reference or benchmark condition (*sensu* DSE 2008). This applies only to any single inter-flood period. As with natural flood frequency, we estimated the critical interval for each flood-dependent EVC based on what is known or surmised of the flooding requirements and tolerances of character species and the physical (including hydrological) conditions at sites of occurrence, particularly in comparison to these parameters for adjoining or similar EVCs.
4. *Estimation of the minimum duration for each flood-dependent EVC.* This is the minimum duration of inundation required to maintain each EVC in a condition referable to its reference state; i.e. the length of time that an EVC is continuously under water for each inundation event, assuming that these are occurring at the frequency necessary to maintain it in a reference state. It is worth noting that this variable is not solely a function of the duration of high river flows. For example, rates of drying or drawdown following flood recession vary according to floodplain geomorphology and greatly affect the duration of flooding in some places compared to others. Again, the minimum duration for each flood-dependent EVC was estimated (by DF and MW) based on what is known or surmised of the flooding requirements and tolerances of character species and the physical (including hydrological) conditions at sites

of occurrence, particularly in comparison to these parameters for adjoining or similar EVCs.

Identifying flood requirements — Rare or threatened flora

The assessment of flooding requirements for each flood-dependent rare or threatened plant taxon was undertaken by DF and MW who were the botanists that assessed the flooding requirements of EVCs. The assessments for rare or threatened taxa followed the same five steps as the EVC assessments, with minor variations as follows:

1. *Identification of flood-dependent rare and threatened plant taxa.* A list of rare or threatened plant taxa (DSE 2005) recorded in the study area was generated using DSE's Flora Information System (FIS) database of Victorian flora records (current to May 2007).² Each taxon on this list was then classed as flood-dependent or not by applying the same definition of 'flood-dependent' that was used for the identification of flood-dependent EVCs to what was known of the taxon's ecology and occurrence, including review of relevant literature and FIS data. As with EVCs, flooding requirements of some species may relate more to maintenance of suitable habitat conditions than to their tolerance of dry conditions (e.g. prevention of salinisation of habitat or reduced competition from species which are less tolerant of flooding). In some cases, species may draw on groundwater resources which may become depleted or saline with a long-term absence of flooding in adjacent areas.
2. *Estimation of the natural flood frequency, critical interval and minimum duration.* For most plant taxa there is little specific information available on flood requirements. Thus for each of these three parameters the estimated natural flood frequency, critical interval and minimum duration of the principal EVCs at sites where the threatened taxon had been recorded were adopted as the estimated values of these parameters for the taxon. We overlaid threatened floodplain flora records with EVCs in a geographic information system. In most cases there was a high fidelity between species and one or a small number of EVCs.

For a relatively small number of these taxa it was not possible to identify a reliable association with any EVC and as a result no estimate was made of these parameters.

3. *Mapping of the current extent of all flood-dependent rare or threatened plant taxa.* The distribution of each flood-dependent rare or threatened plant taxon was mapped using site location records superimposed on EVC maps. Discrete EVC units (or polygons of related host EVCs) located at or very near the flora records were mapped as a surrogate for taxa distribution. This method required sufficiently detailed mapping and accurate species location information. However, in some cases existing mapping was not adequate to substantiate an association at such a detailed level, and a spot location representing the site record was used in place of an EVC polygon. The spot location was attributed a radius reflecting the level of site accuracy (e.g. +/- 50 m attributed a radius of approximately 50 metres). Where there were multiple host EVCs, these typically had very similar or identical flood dependency attributes, while for some others there was variation across the landscape. Some flora species occupy a niche between EVCs, particularly along strips where water recession occurs frequently.

To reduce the possibility that sites mapped as polygons did not actually support the relevant rare or threatened plants, old records (those made prior to 1980) and imprecise records (those that could not be reliably located to within 150 metres) were not used to delineate species-occurrence polygons. As a result, no locations were mapped for some flood-dependent species, some of which may no longer occur in the study area. Additionally, the number of records does not necessarily reflect population size or number of stands. Some records reflect repeated sampling from small or localised populations.

Identifying flood requirements — Threatened fauna

The assessment of flooding requirements for threatened fauna followed the same procedure as that for rare or threatened flora, with the following variations:

1. Threatened vertebrate fauna records (DSE 2007) from the study area were extracted from DSE's Victorian Fauna Database (VFD, also known as the Atlas of Victorian Wildlife) current to May 2007 and Birds Australia's Atlas of Australian Birds data (Birdata, accessed from www.birdata.com.au in January–May 2008).³ Amphibians, reptiles, birds and mammals were considered, but not fishes. Flooding requirements were determined through discussions with experts (see Acknowledgements, below), and through reviewing relevant literature.
2. For most threatened fauna taxa there are many more records in the study area than is typical for rare or threatened plants and their habitat requirements are usually much better known. As a result — and because animals are typically more mobile — the identification and mapping of habitat for threatened fauna was often tailored according to characteristics of particular taxa rather than tying the identification and mapping of habitat closely to the site of every record. For example, for several highly mobile duck species that had been recorded at nearly every wetland in the study area (often just once at temporary wetlands), only sites with repeated records or high counts were identified and mapped. Similarly for many colonial breeding birds, a distinction was made between breeding and non-breeding habitat, with only the former being identified and mapped for those species where availability of non-breeding habitat was not a significant factor in their conservation status. On the other hand, for some highly cryptic species with readily identifiable habitat (such as bitterns), habitat patches without records were identified and mapped on the basis that the species almost certainly occurs in these patches on occasions but have not been recorded due to insufficient survey effort.
3. Reflecting this emphasis on the specific characteristics of some taxa, there were some exceptions to the exclusion of old records (those made prior to 1980) and spatially imprecise records (those that could not be located reliably to within 150 metres). For example, older records of colonially nesting waterbirds were included on the basis that these birds breed infrequently and generation times are therefore

longer. Also, older or imprecise records were often included when identifying sites with repeated records or high counts.

4. The habitats of most fauna taxa were specified as one or more EVCs, which were then mapped as the sites for that taxon within its geographic distribution. The natural flood frequency, critical interval and minimum flood duration estimates for the EVC(s) were then assigned to the sites. However for some taxa, notably colonially nesting waterbirds, more specific information was available (e.g. previously known and mapped breeding sites) was available and used to map site locations and specify watering requirements.
5. Some threatened fauna have been recorded in the relatively small areas mapped as Wetland Formation (EVC no. 74), Bare Rock/Ground (993) and Water Body — Natural or man made (998). Flooding requirements for threatened species in these areas were estimated based on the flooding requirements and tolerances of the relevant threatened species and the physical (including hydrological) conditions at the sites.

Results

Some 110 EVCs were found to be at least partly flood-dependent on the Murray River floodplains (Table 1). The total current extent of these EVCs in the study area is 224 247 ha, of which 162 266 ha are on public land. Natural flooding frequencies ranged from as many as 3–4 flood events every four years for Aquatic Herbland and a further 20 EVCs through to one flood event in 20–40 years for Riverine Chenopod Woodland. Critical intervals to maintain healthy ecosystems ranged from one flood event every two years for around 30 EVCs to one flood every 30–50 years for some Black Box-dominated EVCs. Minimum durations of inundation ranged from less than one month to 6–36 months (Table 1). One hundred and twenty-four rare or threatened plant taxa were classified as at least partly flood-dependent of which 68 were sufficiently well known for their distributions to be mapped reliably (Table 2). Of the 62 threatened vertebrate fauna taxa (excluding fish) found to be flood-dependent (or use flood-dependent habitats), 51 were sufficiently well known for their distributions to

be mapped reliably (Table 3). A visual representation of the critical intervals for EVCs and threatened species is presented in Map D⁴ and Map E⁵ of VEAC (2008).

Discussion and further research

This paper is the first attempt to estimate and document the flood requirements for a wide range of natural values in the Victorian floodplain forests of the Murray Valley. As the flooding requirements are based largely on expert opinion and the limited published literature, it is likely that new knowledge and more in-depth research into individual species and ecosystems will refine these requirements. We strongly encourage further research into this field to determine the flooding requirements or tolerances of indigenous species and communities, and ultimately optimise the use of scarce and expensive environmental water.

The present study was restricted to most terrestrial vertebrates and vascular plant taxa classified as rare or threatened at either state or national levels. The Murray River floodplains have a diverse range of arboreal, terrestrial and aquatic macro- and microinvertebrate species (Ballinger and Yen 2002, Shiel 2002; Suter and Hawking 2002; Yen *et al.* 2002), many of which are reliant (or likely to be reliant) on flooding events. It is also recognised that floodplains and flood events are important for fish along the Murray and its tributaries (Koehn 2002; King 2005; King *et al.* 2005; Jones and Stuart 2008). However, King (2005, p. 121) notes that 'whilst the existing Barmah-Millewa EWA [Environmental Water Allocation] has been operating for a number of years, little is known about how natural and managed flood events influence fish populations in the Forest' and that ongoing research is required.

Ideally, floodplain watering strategies should be formulated on the requirements of all floodplain biota including fish, invertebrates (terrestrial and aquatic), non-vascular plants and regionally significant taxa. Similarly, the list of ecological characteristics used to identify the natural values to be maintained, should be comprehensive and expanded beyond just those for the main sites of occurrence or breeding for threatened taxa to include important characteristics such as the following:

- sites that are likely to assist the recovery of threatened taxa, especially taxa that are highly threatened
- sites of high species richness
- colony sites for colonial breeding species that are not currently classified as threatened
- sites that may be in poor condition at present but would recover with watering and be likely to support significant natural values
- corridors of habitat which are important for the movement of biota — from flight paths for the daily movements of Superb Parrots *Polytelis swainsonii* between breeding and feeding areas to corridors for longer-term movements such as in response to changing climate over the course of decades.

Species distributional data being entered into the Victorian Flora Information System and Atlas of Victorian Wildlife have declined significantly in recent years (Commissioner for Environmental Sustainability 2008). There is an urgent need to reinvest in basic ecological inventory and monitoring to improve our understanding of both the distribution and occurrence of many taxa and to monitor and refine our understanding of the effects and benefits of flood regimes.

The project to date should be seen as an initial step towards a more comprehensive and ongoing analysis that is continually updated and refined as new data and results become available. There are still many gaps in our understanding of the flooding requirements and basic ecology of many of the ecological vegetation classes, and threatened flora and fauna, on the floodplains of the Murray River. It is hoped this project provides a catalyst for ongoing research.

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Notes

- ¹ Email the corresponding author for a copy of the Peake *et al.* (2011) article.
- ² Vascular plant taxa listed under the *Advisory List of Rare or Threatened Plants in Victoria – 2005* (DSE 2005), the *Victorian Flora and Fauna Guarantee Act 1988* or the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*.
- ³ Vertebrate taxa other than fish listed under the *Advisory List of Threatened Vertebrate Fauna in Victoria – 2007* (DSE 2007), the *Victorian Flora and Fauna Guarantee Act 1988* or the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*.
- ⁴ http://www.veac.vic.gov.au/maps/352-MapD_Flood_Dependent_EVCs.pdf
- ⁵ http://www.veac.vic.gov.au/maps/352-MapE_Flood_Dependent_threatened_species.pdf

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Table 1. Natural flood frequency, critical interval and minimum duration of flood-dependent Ecological Vegetation Classes (EVCs) in the VEAC River Red Gum Forests investigation area. v = variable.

EVC No.	Ecological Vegetation Class (EVC)	Natural flood frequency (years)	Critical interval (years)	Minimum duration (months)
806	Alluvial Plains Semi-arid Grassland	1 in 2-15	25	1.5-6
653	Aquatic Hermland	3-4 in 4	2	6-12
1043	Aquatic Hermland/Floodplain Grassy Wetland Mosaic	7-10 in 10	2	3-9
1044	Aquatic Hermland/Floodway Pond Hermland	3-4 in 4	2	6-12
1045	Aquatic Hermland/Riverine Swamp Forest Mosaic	3-4 in 4	2	6-12
1047	Aquatic Hermland/Tall Marsh Mosaic	3-4 in 4	2	6-12
334	Billabong Wetland Aggregate	variable	2 (v)	>6
297	Billabong Wetland Aggregate/Red Gum Swamp Mosaic	variable	2 (v)	>6
807	Disused Floodway Shrubby Hermland	1 in 10-20	25 (v)	2-6 (v)
1022	Drainage-line Aggregate	3-5 in 5	2	2-12
1023	Drainage-line Aggregate/Riverine Swamp Forest Mosaic	3-4 in 5	3	4-7
1025	Drainage-line Aggregate/Sedgy Riverine Forest Mosaic	1-3 in 5	5	1-2
168	Drainage-line Aggregate/Tall Marsh Mosaic	3-5 in 5	2	2-12
809	Floodplain Grassy Wetland	7-10 in 10	2	3-9
1049	Floodplain Grassy Wetland/ Floodway Pond Hermland Mosaic	7-10 in 10	2	3-9
1051	Floodplain Grassy Wetland/ Riverine Swamp Forest Mosaic	7-10 in 10	2	3-9
1052	Floodplain Grassy Wetland/ Riverine Swampy Woodland Mosaic	7-10 in 10	2	3-9
1054	Floodplain Grassy Wetland/Spike-sedge Wetland Mosaic	7-10 in 10	2	3-9
1055	Floodplain Grassy Wetland/Tall Marsh Mosaic	7-10 in 10	2	3-9
56	Floodplain Riparian Woodland	3-5 in 10	7	<1
1033	Floodplain Riparian Woodland/ Floodway Pond Hermland Mosaic	6-9 in 10	3	4-10
1031	Floodplain Riparian Woodland/ Grassy Riverine Forest Mosaic	2-4 in 4	4	1-4
1032	Floodplain Riparian Woodland/ Riverine Grassy Woodland Mosaic	3-5 in 10	7	<1
1034	Floodplain Riparian Woodland/ Riverine Swamp Forest Mosaic	3-4 in 5	3	4-7
1035	Floodplain Riparian Woodland/ Sedgy Riverine Forest Mosaic	1-3 in 5	5	1-2
1037	Floodplain Riparian Woodland/Tall Marsh Mosaic	3-5 in 5	2	6-11
172	Floodplain Wetland Aggregate	3-4 in 4	2	2-9
810	Floodway Pond Hermland	6-9 in 10	3	4-10
945	Floodway Pond Hermland/Riverine Swamp Forest Complex	3-5 in 5	3	3-8
1058	Floodway Pond Hermland/Riverine Swamp Forest Mosaic	6-9 in 10	3	4-10
1060	Floodway Pond Hermland/Tall Marsh Mosaic	6-9 in 10	3	4-10
106	Grassy Riverine Forest	2-4 in 4	4	1-4
1015	Grassy Riverine Forest/Drainage-line Aggregate Mosaic	2-4 in 4	4	3-6
811	Grassy Riverine Forest/Floodway Pond Hermland Complex	2-4 in 4	4	3-6
1029	Grassy Riverine Forest/Floodway Pond Hermland Mosaic	2-4 in 4	4	3-6

Table 1. (cont.)

Ecological Vegetation Class (EVC)

EVC No.	Ecological Vegetation Class (EVC)	Natural flood frequency (years)	Critical interval (years)	Minimum duration (months)
1017	Grassy Riverine Forest/Riverine Grassy Woodland Mosaic	2-4 in 4	4	1-4
812	Grassy Riverine Forest/Riverine Swamp Forest Complex	3-5 in 5	3	3-6
1030	Grassy Riverine Forest/Riverine Swamp Forest Mosaic	3-5 in 5	3	3-6
1062	Grassy Riverine Forest/Riverine Swampy Woodland Mosaic	2-4 in 4	4	1-4
1063	Grassy Riverine Forest/Sedgy Riverine Forest Mosaic	2-4 in 4	4	1-4
1065	Grassy Riverine Forest/Tall Marsh Mosaic	3-5 in 5	2	6-11
813	Intermittent Swampy Woodland	1-3 in 5	7	2-6
822	Intermittent Swampy Woodland/ Riverine Grassy Woodland Complex	1-5 in 10	10	<1-3
107	Lake Bed Hermland	variable	2-5 (v)	6-36
808	Lignum Shrubland	1 in 4-10	15	2-4
104	Lignum Swamp	1 in 2-8	15	2-6
823	Lignum Swampy Woodland	1 in 2-8	15	2-4
1038	Low Rises Woodland/Riverine Swampy Woodland Mosaic	1 in 2-8	15	2-4
1048	Mosaic of Aquatic Hermland/ Floodway Pond Hermland-Riverine Swamp Forest Complex	1-3 in 5	5	<1-2
1046	Mosaic of Aquatic Hermland/ Sedgy Riverine Forest-Riverine Swamp Forest Complex	3-4 in 4	2	6-12
1039	Mosaic of Drainage-line Aggregate/ Floodway Pond Hermland-Riverine Swamp Forest Complex	3-4 in 4	2	6-12
1021	Mosaic of Drainage-line Aggregate/ Grassy Riverine Forest-Riverine Swamp Forest Complex	3-5 in 5	3	3-8
1024	Mosaic of Drainage-line Aggregate/ Sedgy Riverine Forest-Riverine Swamp Forest Complex	3-5 in 5	3	3-6
1056	Mosaic of Floodplain Grassy Wetland/ Floodway Pond Hermland-Riverine Swamp Forest Complex	3-4 in 5	3	2-5
1050	Mosaic of Floodplain Grassy Wetland/ Grassy Riverine Forest-Riverine Swamp Forest Complex	7-10 in 10	2	3-9
1053	Mosaic of Floodplain Grassy Wetland/ Sedgy Riverine Forest-Riverine Swamp Forest Complex	7-10 in 10	2	3-9
1036	Mosaic of Floodplain Riparian Woodland/ Sedgy Riverine Forest-Riverine Swamp Forest Complex	3-4 in 5	3	2-5
1057	Mosaic of Floodway Pond Hermland/ Grassy Riverine Forest-Riverine Swamp Forest Complex	6-9 in 10	3	3-10
1059	Mosaic of Floodway Pond Hermland/ Sedgy Riverine Forest-Riverine Swamp Forest Complex	6-9 in 10	3	3-10
1020	Mosaic of Grassy Riverine Forest/ Floodway Pond Hermland-Riverine Swamp Forest Complex	3-5 in 5	3	3-8
1016	Mosaic of Grassy Riverine Forest/ Plains Grassy Woodland-Grassy Woodland Complex	2-4 in 4	4	1-4
1019	Mosaic of Grassy Riverine Forest/ Sedgy Riverine Forest-Riverine Swamp Forest Complex	2-4 in 4	4	1-4
1061	Mosaic of Grassy Riverine Forest-Riverine Swamp Forest Complex/Riverine Swamp Forest	3-4 in 5	3	4-7
1042	Mosaic of Riverine Grassy Woodland/ Floodway Pond Hermland-Riverine Swamp Forest Complex	3-5 in 5	3	3-8
1072	Mosaic of Riverine Swamp Forest/ Floodway Pond Hermland-Riverine Swamp Forest Complex	3-5 in 5	3	3-8
1074	Mosaic of Riverine Swampy Woodland/ Sedgy Riverine Forest-Riverine Swamp Forest Complex	3-4 in 5	3	2-5
1078	Mosaic of Sedgy Riverine Forest/ Floodway Pond Hermland-Riverine Swamp Forest Complex	3-5 in 5	3	3-8
1075	Mosaic of Sedgy Riverine Forest/ Sedgy Riverine Forest-Riverine Swamp Forest Complex	3-4 in 5	3	2-5
1080	Mosaic of Sedgy Riverine Forest-Riverine Swamp Forest Complex/Floodway Pond Hermland-Riverine Swamp Forest Complex	3-5 in 5	3	3-8
1079	Mosaic of Sedgy Riverine Forest-Riverine Swamp Forest Complex/Tall Marsh	3-4 in 5	3	2-5

Table 1. (cont.)

EVC No.	Ecological Vegetation Class (EVC)	Natural flood frequency (years)	Critical interval (years)	Minimum duration (months)
1083	Mosaic of Tall Marsh/Floodway Pond Herbland-Riverine Swamp Forest Complex	3-5 in 5	3	3-8
125	Plains Grassy Wetland	2-3 in 3	3	3-8
238	Plains Grassy Woodland/Creekline Grassy Woodland/Floodplain Riparian Woodland Mosaic	3-5 in 10	7	<1
292	Red Gum Swamp	2-3 in 3	3	4-9
333	Red Gum Swamp/Plains Grassy Wetland Mosaic	2-3 in 3	3	4-9
103	Riverine Chenopod Woodland	1 in 10-25 (1 in 20-40 <i>Atriplex</i> community)	30-50	<1-3
321	Riverine Chenopod Woodland/Lignum Swamp Mosaic	1 in 2-8	15	2-6
295	Riverine Grassy Woodland	2-3 in 10	7	<1
1027	Riverine Grassy Woodland/Grassy Riverine Forest-Riverine Swamp Forest Complex	3-5 in 5	3	3-6
870	Riverine Grassy Woodland/Plains Woodland Complex	2-3 in 10	7	<1
871	Riverine Grassy Woodland/Plains Woodland/Gilgai Wetland Complex	2-3 in 10	7	<1
872	Riverine Grassy Woodland/Plains Woodland/Riverine Chenopod Woodland Complex	1 in 10-25 (1 in 20-40 <i>Atriplex</i> community)	30-50	2-4
873	Riverine Grassy Woodland/Riverine Chenopod Woodland/Wetland Mosaic	2-3 in 10	7	<1
1028	Riverine Grassy Woodland/Riverine Swamp Forest Mosaic	3-4 in 5	3	4-7
1040	Riverine Grassy Woodland/Riverine Swampy Woodland Mosaic	1-3 in 5	5	<1-2
1041	Riverine Grassy Woodland/Sedgy Riverine Forest Mosaic	1-3 in 5	5	<1-2
814	Riverine Swamp Forest	3-4 in 5	3	4-7
1067	Riverine Swamp Forest/Riverine Swampy Woodland Mosaic	3-4 in 5	3	4-7
1068	Riverine Swamp Forest/Sedgy Riverine Forest Mosaic	3-4 in 5	3	4-7
1069	Riverine Swamp Forest/Sedgy Riverine Forest-Riverine Swamp Forest Complex	3-4 in 5	3	4-7
1070	Riverine Swamp Forest/Spike-sedge Wetland Mosaic	2-4 in 4	4	1-4
1071	Riverine Swamp Forest/Tall Marsh Mosaic	3-5 in 5	2	6-11
815	Riverine Swampy Woodland	1-3 in 5	5	<1-2
1099	Riverine Swampy Woodland/Plains Grassy Wetland Mosaic	2-3 in 3	3	3-8
1073	Riverine Swampy Woodland/Sedgy Riverine Forest Mosaic	1-3 in 5	5	1-2
804	Rushy Riverine Swamp	3-4 in 5	2	3-9
816	Sedgy Riverine Forest	1-3 in 5	5	1-2
817	Sedgy Riverine Forest/Riverine Swamp Forest Complex	3-4 in 5	3	4-7
1076	Sedgy Riverine Forest/Spike-sedge Wetland Mosaic	2-4 in 4	4	1-4
1077	Sedgy Riverine Forest/Tall Marsh Mosaic	3-5 in 5	2	6-11
200	Shallow Freshwater Marsh	2-3 in 3	3	4-9
818	Shrubby Riverine Woodland	1-3 in 5	7	<1

Table 1. (cont.)

EVC No.	Ecological Vegetation Class (EVC)	Natural flood frequency (years)	Critical Minimum interval duration (years) (months)
819	Spike-sedge Wetland	2-4 in 4	4
1081	Spike-sedge Wetland/Tall Marsh Mosaic	3-5 in 5	2
820	Sub-saline Depression Shrubland	1 in 10-15	2.5
821	Tall Marsh	3-5 in 5	2
1087	Tall Marsh/Aquatic Herbland Mosaic	3-4 in 4	2
1084	Tall Marsh/Non-Vegetation Mosaic	3-4 in 4	2
1090	Tall Marsh/Open Water Mosaic	3-4 in 4	2
1082	Tall Marsh/Riverine Swamp Forest Mosaic	3-5 in 5	2
Flood-dependent EVCs found in the VEAC River Red Gum Forests Investigation area but not in the present study			
291	Cane Grass Wetland	2-4 in 5	5
942	Lignum Swampy Woodland/Lake Bed Herbland Mosaic	variable	2-5 (v)
943	Lignum Swampy Woodland/ Plains Grassland Mosaic	1 in 2-8	15
855	Plains Woodland/Lignum Swamp Mosaic	1 in 2-8	15
856	Plains Woodland/Red Gum Swamp Mosaic	2-3 in 3	3
110	Riverine Chenopod Woodland/Plains Grassland Mosaic	1 in 10-25 (1 in 20-40 <i>Atriplex</i> community)	30-50
946	Riverine Swampy Woodland/Lignum Swamp Mosaic	1 in 2-8	15
			2-6

Note that the broad EVCs 'Water Body - natural or man made' (998) and 'Wetland Formation' (74) are at least in some cases flood-dependent. 'Bare Rock/ Ground' (993) EVC has in some cases been mapped for dry creek beds or billabongs which would be flood-dependent, particularly in the northwest of the study area.

Table 2. Flood requirements of rare or threatened flora

Conservation status: E = endangered, V = vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*; e = endangered, v = vulnerable, r = rare, k = poorly known on the *Advisory List for Rare and Threatened Plants in Victoria - 2005*; L = Listed under the *Victorian Flora and Fauna Guarantee Act 1988*.

Wetland/Floodplain Dependent: Y - Taxa apparently requiring/responding to inundation, N - Taxa not dependent on riverine flooding, H - Taxa occurring in habitats which are prone to at least some inundation, O - taxa that are 'inter-flood colonisers' (i.e. they occur in areas that are occasionally flood-prone but also elsewhere). They may be intolerant of short periods of inundation but also extensive absences of flooding.

Importance of Study Area Population: H = high - substantial proportion of at least northern populations within study area, or very few localities in total or Northern Plains populations largely extinct. M = moderate - regional and state survival not dependent on populations within study area, but more than incidental relevance of distribution within study area (including Northern Plains populations largely extinct).

Relevant Flood-Dependent EVCs: numbers refer to EVC numbers in Table 1.

Mapped: ✓ = Yes, ✗ = No

Name and conservation status	Wetland/ floodplain dependent*	Importance of study area population	Relevant flood-dependent EVCs	Mapped	Additional information
Native Scurf-pea <i>Cullen australasicum</i> (e, L)	Y	H	107	✗	Drying phase of shallow lakes
Hoary Scurf-pea <i>Cullen cinereum</i> (e, L)	Y	H	107	✓	
Small Scurf-pea <i>Cullen parvum</i> (e, L)	Y (in north)	H	816 (upper edge), 815	✓	Upper edge of flooded zone, flood-dispersed seed pods
Annual Flat-sedge <i>Cyperus nervulosus</i> (e, L)	Y	H	1022 / 814, Riparian	✗	
Slender Love-grass <i>Eragrostis exigua</i> (e)	Y	H	1022	✓	
Grey Billy-buttons <i>Craspedia canens</i> (e, L)	N/Y	H?	172, 125 &/or 815?	✗	
Plains Spurge <i>Euphorbia planiticola</i> (e, L)	N/Y?	H?	107 / 813?	✗	
Keeled Goosefoot <i>Chenopodium carinatum</i> (v)	H/Y?	H?	985 / 810 / 1022 /Riparian?	✗	
Jerry-jerry <i>Ammannia multiflora</i> (v)	Y	H	1022, 808, 107, 806	✓	Annual of creeklines, lacustrine - following recession Restricted to drying phase of lake beds and lagoons
Small Water-fire <i>Bergia trimera</i> (v)	Y	H	107	✓	
Mueller Daisy <i>Brachyscome muellerioides</i> (V, e, L)	Y/H	H	295, 815	✓	
Water-shield <i>Brasenia schreberi</i> (v, L)	Y	H	334, 653/998	✗	
Western Water-starwort <i>Callitriche cyclocarpa</i> (V, v, L)	Y	H	1022 / 998, 810, 945, 812	✓	Floodways and wetlands - small seasonal aquatic, required shallow open habitat
Lax Flat-sedge <i>Cyperus flaccidus</i> (v)	Y	H	1022 / 814, Riparian	✗	Verges of drainage-lines / floodways
Dwarf Flat-sedge <i>Cyperus pygmaeus</i> (v)	Y	H	1022 / 814, Riparian	✓	Verges of drainage-lines / floodways

Table 2 (cont.)
Name and conservation status

Name and conservation status	Wetland/ flood-plain dependent*	Importance of study area population	Relevant flood-dependent EVCs	Mapped	Additional information
Bearded Flat-sedge <i>Cyperus squarrosus</i> (v)	Y	H	1022 / 814, Riparian	✓	
Button Rush <i>Lipocarpus microcephala</i> (v)	Y	H	810, 1022, 172, 998	✓	Annual of sandy floodways - following recession
Lagoon Spurge <i>Phyllanthus lacunarius</i> (v)	Y	H	808	✓	Restricted to drying phase of lake beds and lagoons
Glistening Dock <i>Rumex crystallinus</i> s.s. (v)	Y	H	806 / 107, 808, 811	✗	Post-recession annual of low herblands
Yellow Pea-bush <i>Sesbania cannabina</i> var. <i>cannabina</i> (v)Y?	Y	H?	810 / 172?	✗	
Lagoon Nightshade <i>Solanum lacunarium</i> (v)	Y	H	808, 806	✓	Restricted to drying phase, lakes and lagoons
Wavy Marshwort <i>Nymphoides crenata</i> (v)	Y	H	shallow wetlands / verges of 1022, 653, 809, 945, 172, 334, 810 (marginal)	✓	Aquatic herb, floodways and related wetlands
Twin-leaf Bedstraw <i>Asperula gemella</i> (r)	Y	H	808, 104, 823, 106 (north-west only), 818, 103, 813	✓	
Reader's Daisy <i>Brachyscome readeri</i> (r)	Y/H	H	295, 815	✓	
Cotton Sneezeweed <i>Centipeda nidiformis</i> (r)	Y	H	810, 809, 945	✓	
Veiled Fringe-sedge <i>Fimbristylis velata</i> (r)	Y	H	1022, 810, 172	✗	
Dwarf Brooklime <i>Gratiola pumilo</i> (r)	Y	H	1022	✗	
Hydrilla <i>Hydrilla verticillate</i> (r)	Y	H	653, 998, 1022	✗	
Brown Beetle-grass <i>Leptochloa fusca</i> subsp. <i>fusca</i> (r)	Y	H	810/1022?	✗	
Small Monkey-flower <i>Mimulus prostrates</i> (r)	N/Y	H	813?, 823 / 808?	✗	
Mallice Cucumber <i>Mukia micrantha</i> (r)	Y	H/M	107, 806, 810 (north-west)	✓	Restricted to drying phase of shallow lakes
Water Nymph <i>Najas tenuifolia</i> (r)	Y	H	653, Riparian, 998	✗	
Sandhill Spurge <i>Phyllanthus lacunellus</i> (r)	Y	H	806, 107, 808	✓	
Dwarf Bitter-cress <i>Rorippa eustylis</i> (r)	Y	H	810, 811, 812, 817	✓	Annual of flood-prone sites
Floodplain Fireweed <i>Senecio glandulosus</i> (r)	Y	H	295 / 56?	✗	
Yakka Grass <i>Sporobolus caroli</i> (r)	Y/H	H/M	103	✓	
Sweet Fenugreek <i>Trigonella suavissima</i> (r)	Y	H	107, 813	✓	Restricted to drying phase of lakes/ lagoons and associated floodways

Table 2 (cont.)
Name and conservation status

	Wetland/ flood-plain dependent*	Importance of study area population	Relevant flood-dependent EVCs	Mapped	Additional information
Common Joyweed <i>Alternanthera nodiflora</i> (k)	Y	H	809, 813, 806, 808, 1022, 810	✓	
Common Hornwort <i>Ceratophyllum demersum</i> (k)	Y	H	653, 998 / Riparian	✗	
Native Couch <i>Cynodon dactylon</i> var. <i>pulchellus</i> (k)	Y	H	816, 106, 817, 812, 823 (north-west), 295, 1022, 945, 813, 818, 809 (marginal), 811	✓	
Yelka <i>Cyperus victoriensis</i> (k)	Y	H	1022 / 814, Riparian	✗	Verges of drainage-lines / floodways
Tall Cup-grass <i>Eriochloa crebra</i> (k)	Y	H	813/1022?, potentially 806, 823	✗	
Summer Fringe-sedge <i>Fimbristylis aestivalis</i> (k)	Y	H	1022, 810, 172	✓	
Native Peppergrass <i>Lepidium pseudohyssopifolium</i> (k)	Y	H	806, 818, 103, 813, 106, 808, 295, 811 (minor)	✓	
Indian Chickweed <i>Mollugo verticillate</i> (k)	Y?	H?	56 / 172?	✗	
Velvet Knotweed <i>Persicaria attenuate</i> (k)	Y	H	107, 810, 172	✗	Restricted to drying phase of lake beds and lagoons/billabongs
Tongue Dock <i>Rumex stenoglotis</i> (k)	Y	H	810 / 1022?	✗	
Smooth Blue-rod <i>Stemodia glabella</i> s.s. (k)	Y	H	818, 813	✗	
Perfoliate Pondweed <i>Potamogeton perfoliatus</i> s.s. (k)	Y	M/H	653, Riparian, 998	✗	
River Swamp Wallaby-grass <i>Amphibromus fluitans</i> (V) Y	Y	H	814, 809, 1022, 804 (minor 821, 945, 815, 817)	✓	
Curly Flat-sedge <i>Cyperus rigidellus</i> (s, L)	Y	M	1022 / 814, Riparian	✗	
Umbrella Grass <i>Digitaria divaricatissima</i> (v)	Y	M	103, 813	✗	
Cane Grass <i>Eragrostis australasica</i> (v)	Y	M	808, extending into 823, 103	✓	
Ridged Water-milfoil <i>Myriophyllum porcatum</i> (V, v, L) Y	Y	M	125, 653	✗	
Small-flower Tobacco <i>Nicotiana goodspeedii</i> (r)	Y	M	107, 813	✗	
Slender Water-ribbons <i>Triglochin dabia</i> (r)	Y	M	823, 1022, 808?	✗	
Plains Billy-buttons <i>Craspedia haplorrhiza</i> (k)	Y	M	808, 104	✗	
Pale Spike-sedge <i>Eleocharis pallens</i> (k)	Y	M	806, 172	✓	
Hypselia <i>Hypselia tridens</i> (k)	Y	M	945, 1022, 810, 998, 334, 172	✗	
Slender Bitter-cress <i>Cardamine tenuifolia</i> (k)	N/Y	M	56	✗	

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Volume 127 number 6 was a special issue in
memory of Clarrie Handreck

Table 2. (cont.)
Name and conservation status

	Wetland/ flood-plain dependent*	Importance of study area population	Relevant flood-dependent EVCs	Mapped	Additional information
Dwarf Darling-pea <i>Swainsona luteola</i> (e, L)	H?	H	103	✗	
Straggly Lantern-bush <i>Abutilon oxycarpum</i> var. <i>malvaefolium</i> (e, L)	H	H	103	✓	
Silky-heads <i>Cymbopogon oblectus</i> (e)	H	H	106 / 56?	✗	
Winged Peppercress <i>Lepidium monoplacoides</i> (E, e, L)	H	H	103	✓	
Fat Spectacles <i>Menkea crassa</i> (e, L)	H	H	103	✗	
Yellow Tails <i>Ptilotus nobilis</i> var. <i>nobilis</i> (e)	H	H	103	✓	
Slender Sunray <i>Rhodanthe stricta</i> (e, L)	H	H	295 (or interface with very infrequently flooded 803?)	✗	
Woolly Copperburr <i>Sclerolaena lanicuspis</i> (e)	H	H	807 / 808 / 103?	✗	
Salt Copperburr <i>Sclerolaena ventricosa</i> (e, L)	H	H	808?	✗	
Violet Swainson-pea <i>Swainsona adenophylla</i> (e, L)	H	H	295 / 1088	✗	
Hairy Darling-pea <i>Swainsona greyana</i> (e, L)	H	H	818	✓	Restricted to very localised flood- plain habitat, flood-dispersed seed pods
Pop Saltbush <i>Atriplex holocarpa</i> (v, L)	H	H	103, 107, 808	✗	
Spreading Saltbush <i>Atriplex limbata</i> (v, L)	H	H	103	✓	
Billabong Daisy <i>Brachyscome</i> aff. <i>gracilis</i> (Kings Billabong) (v, L)	H	H	813	✓	Restricted to very localised flood- plain habitat
Yellow Garland-lily <i>Calostemma luteum</i> (v)	H	H	818, 103	✗	
Darling Lily <i>Grimmia flaccidum</i> (v, L)	H	H	1022 / 818, 103	✗	
Riverine Flax-lily <i>Dianella porracea</i> (v)	H	H	103	✓	
Pale Flax-lily <i>Dianella</i> sp. aff. <i>longifolia</i> (Riverina) (v)	H	H	816, 295	✓	
Flycatcher <i>Drosera indica</i> (v)	H	H	813	✗	
Tall Nut-heads <i>Epaltes cunninghamii</i> (v)	H	H	103, 813	✗	
Bignonia Emu-bush <i>Eremophila bignoniiflora</i> (v, L)	H	H	103, 818	✓	Shrub of Black Box woodlands, with flood-dispersed seed pods
Poverty Bush <i>Sclerolaena intricata</i> (v)	H	H	820, 808	✓	
Pale Swamp Everlasting <i>Helichrysum</i> aff. <i>rutidolepis</i> (Lowland Swamps) (v)	H	H (riverine form)	295, 815, 816	✓	Herbs of upper floodplain zones, habitat flood maintained

Table 2. (cont.)
Name and conservation status

	Wetland/ flood-plain dependent*	Importance of study area population	Relevant flood-dependent EVCs	Mapped	Additional information
Dwarf Old-man Saltbush					
<i>Atriplex nummularia</i> subsp. <i>omissa</i> (r)	H	H	103	✗	
Garland Lily <i>Calostemma purpureum</i> s.s. (r)	H	H	818, 103	✓	
Riverina Bitter-cross <i>Cardamine moitrensis</i> (r)	H	H	106, 812, 814, 816, 817, 811, (& 809, 810)	✓	Restricted to flood maintained habitat, vulnerable to gross habitat changes
Spreading Emu-bush					
<i>Eremophila divaricata</i> subsp. <i>divaricata</i> (r)	H	H	103, 813	✓	
Spotted Emu-bush <i>Eremophila maculata</i> var. <i>maculata</i> (r)	H	H	103, 813	✓	
Woolly Minuria <i>Minuria denticulata</i> (r)	H	H	808	✗	
Squat Picris <i>Picris squarrose</i> (r)	H	H	818, 295 (and extending into 945 and 811 during sustained dry periods)	✓	
Bundled Peppergrass <i>Lepidium fasciculatum</i> (k)	H	H	808, 104, 823, 103	✓	
Warty Peppergrass <i>Lepidium papillosum</i> (k)	H	H	103, 806, 808	✓	
Tangled Copperburr <i>Sclerolaena divaricata</i> (k)	H	H	808, 104, 823, also 103?	✓	
Bluish Raspwort <i>Haloragis glauca</i> f. <i>glauca</i> (k)	H	M	813, 107, 823	✓	
Weeping Myall <i>Acacia pendula</i> (e, L)	H/O	H	103	✓	
Soda Bush <i>Neobassia proceriflora</i> (e)	H/O	H	103	✓	
Small-leaf Bluebush <i>Maireana microphylla</i> (e)	H/O	H/M	295	✓	
Pale Plover-daisy <i>Leiocarpa leptolepis</i> (e, L)	H/O	M	103, 295	✓	
Desert Lantern <i>Abutilon otocarpum</i> (v)	H/O	H	103, 813	✓	
Yarran <i>Acacia melvillei</i> (v)	H/O	H	103	✓	
Dwarf Amaranth <i>Amaranthus macrocarpus</i> var. <i>macrocarpus</i> (v)	H/O	H	103	✓	
Silver Saltbush <i>Atriplex rhagodioides</i> (v)	H/O	H	103	✓	
Purple Love-grass <i>Eragrostis lacunaria</i> (v)	H/O	H	103, 813, 806 / marginal 809 extending into 807, 103	✓	from drier shrublands?, possibly 808?
Spear-fruit Copperburr <i>Sclerolaena patentiscuspis</i> (v)	H/O	H		✓	

Table 2. (cont.)

Name and conservation status	Wetland/ flood-plain dependent*	Importance of study area population	Relevant flood-dependent EVCs	Mapped	Additional information
Annual Bitter-creed <i>Cardamine paucijuga</i> s.s. (v)	H/O	M	56/172?	✓	
Mealy Saltbush <i>Atriplex pseudocampaulata</i> (t)	H/O	H	103	✓	
Prickly Bottlebrush <i>Callistemon brachyandrus</i> (r)	H/O	H	103	✓	
Blue Burr-daisy <i>Calotis cuneifolia</i> (r)	H/O	H	818, 295	x	
Finger Grass <i>Dactyloctenium radulans</i> (t)	H/O	H	103	✓	
Goat Head <i>Malacocera tricornis</i> (r)	H/O	H	103, 808, 820	✓	
Smooth Minuria <i>Minuria integerrima</i> (r)	H/O	H	103, 815	x	
Mallee Annual-bluebell					
<i>Wahlenbergia tumidiflora</i> (r)	H/O	H	103?, 815?	x	
Wimmera Woodruff <i>Asperula wimmerana</i> (r)	H/O	M	823	✓	
Spiny Lignum <i>Muehlenbeckia horrida</i>					
subsp. <i>horrida</i> (r)	H/O	M	107, 806, 813	x	
Flat-top Saltbush <i>Atriplex lindleyi</i>					
subsp. <i>lindleyi</i> (k)	H/O	H	103	x	
Bladder Saltbush <i>Atriplex vesicaria</i>					
subsp. <i>minor</i> (k)	H/O	H	103	x	
Ferny Small-flower Buttercup					
<i>Ranunculus pumilio</i> var. <i>politus</i> (k)	H/O	H	817, 814	x	
Austral Trefoil <i>Lotus australis</i> var. <i>australis</i> (k)	H/O	H (riverine form)	818, 295	x	
Leafless Bluebush <i>Maireana aplylla</i> (k)	H/O	M	103	x	
Desert Spinach <i>Tetragonia eremaea</i> s.s. (k)	H/O	M	808, 806, 103	✓	
Annual Spinach <i>Tetragonia moorei</i> (k)	H/O	M	103	✓	
Native Maddler <i>Synaptantha tilleacea</i>					
var. <i>tilleacea</i> (v)	?	H?	810?	x	
Long Eryngium <i>Eryngium paludosum</i> (v)	Y	M	104, 823	✓	
Swamp Buttercup <i>Ranunculus undosus</i> (v)	Y	M	104, 823	✓	

Note: Where populations also occur in non-flooded Chenopod Shrubland EVC communities or adjacent dry woodland habitats, they are denoted H/O unless there is information to suggest that the occurrences within Riverine Chenopod Woodland (EVC 103) are of only incidental importance to overall populations.

Table 3. Flood requirements of threatened fauna in the River Red Gum study area. **Conservation status:** E = endangered, V = vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*; ce = critically endangered, e = endangered, v = vulnerable, d = data deficient, n = near threatened on the *Advisory List for Threatened Vertebrate Fauna in Victoria – 2007*; L = Listed under the *Victorian Flora and Fauna Guarantee Act 1988*. **Abbreviations – EVC:** Ecological Vegetation Class, **VFD:** Victorian Fauna Database/Atlas of Victorian Wildlife, **FFG:** Victorian *Flora and Fauna Guarantee Act 1988*.

Species and conservation status	Location and flood requirements
Brown Quail <i>Coturnix ypsilophora</i> (n)	<p>Sites mapped:</p> <ol style="list-style-type: none"> All areas of Floodplain Riparian Woodland, Spike Sedge Wetland, Intermittent Swampy Woodland and mosaics or complexes containing one or more of these in Gunbower Forest, Hattah–Kulkyne National Park and Murray–Kulkyne National Park and Lower Goulburn Forests from (1) its junction with the Murray River to Wyuna and including Kanyapella and (2) Loch Garry upstream (to furthest point upstream in study area). All areas of these EVCs and mosaics or complexes containing these EVCs within 2 km of all record sites. <p>Minimum flood frequency: as per EVCs above. Flood duration: as per EVCs.</p> <p>Habitat/Location: Very widespread but sparse along or just outside entire study area. Habitat described by Emison <i>et al.</i> (1987) as ‘grass and sedge flats ... grassy River Red Gum forests and ... wet woodlands and forests containing grasses, sword-sedges and gahnia’s’. In instances where there are three or more recent records, all suitable EVC areas in blocks have been selected (there are two records in each of Barmah and Lower Ovens).</p> <p>Relative importance of study area: ‘Only’ near threatened, widespread outside study area in Australia and, to a lesser extent Victoria.</p>
Blue-billed Duck <i>Oxyura australis</i> (e, L)	<p>Sites mapped:</p> <ol style="list-style-type: none"> Lakes Ranfurley and Hawthorn and Hattah–Kulkyne National Park: all areas of Lake Bed Herbland. Kings Billabong: all areas mapped as Bare Rock/Ground. Lake Powell: all areas of Lake Bed Herbland. Reedy Swamp: all areas of Tall Marsh/Open Water Mosaic. Gemmill Swamp: Spike-sedge Wetland/Tall Marsh Mosaic. <p>Minimum flood frequency: as per EVCs; 1 in 2 for Bare Rock/Ground. Flood duration: as per EVCs; 6–12 months for Bare Rock/Ground.</p> <p>Habitat/Location: Included is non-breeding habitat (open wetlands) where there are two or more records, and breeding habitat where there is one or more records — excluding sewage farms (where there are many records) and old or imprecise records. The only breeding records in the study area are at Woodonga Sewage Farm (excluded) and Lake Tullamook near Lake Brockie in the Hattah Lakes. Habitat determinations are as used in Marchant and Higgins (1990) and Emison <i>et al.</i> (1987) — note that the requirement of deep wetlands for breeding excludes about half a dozen otherwise appropriate sites with single records (including at Lindsay Island, south of Kings Billabong, near Wangaratta and near Lake Moodemere).</p> <p>Relative importance of study area: Although endangered in Victoria, the study area probably accounts for less than 10% of Victorian records, and the species is widespread and at least relatively common outside the study area in Victoria and Australia.</p>

Table 3. (cont.)
Species and
conservation status

<p>Musk Duck <i>Biziura lobata</i> (v)</p>	<p>Location and flood requirements</p> <p>Sites mapped:</p> <ol style="list-style-type: none"> 1. Kings Billabong: areas of Bare Rock/Ground. 2. Hattah–Kulkyne National Park and Lakes Powell and Carpul: all areas of Lake Bed Herbland. 3. Vinifera Forest: all areas of Spike-sedge Wetland and Tall Marsh. 4. Gunbower Forest: all areas of Spike-sedge Wetland. 5. Loch Garry: all areas of Billabong Wetland Aggregate and Rushy Riverine Swamp. 6. Reedy Swamp: all areas of Tall Marsh/Open Water Mosaic. 7. Gemmill Swamp: Spike-sedge Wetland/Tall Marsh Mosaic. 8. Barmah Lake: all areas of Water Body – natural or man made. 9. Top Island (Barmah Forest): all areas of Tall Marsh, Rushy Riverine Swamp, and Mosaic of Tall Marsh/Floodway Pond Herbland–Riverine Swamp Forest Complex within 1 km of record. 10. Lake Moodemere: Water Body – natural or man made, Floodplain Wetland Aggregate and Tall Marsh/Aquatic Herbland Mosaic. 11. Ryans Lagoon: all areas of Billabong Wetland Aggregate. <p>Minimum flood frequency: as per EVCs; 1 in 2 for Bare Rock/Ground and Water Body. Flood duration: as per EVCs; 6–12 months for Bare Rock/Ground and Water Body. Habitat/Location: Only sites with two or more records in suitable habitat (except sewage farms) (there are a dozen or so sites in the study area with fewer than two records or where little or no suitable habitat exists). EVCs reflect habitat descriptions used in Marchant and Higgins (1990) and Emison <i>et al.</i> (1987): deep, open wetlands. Breeding records at Lake Bulla, Gemmill Swamp and Reedy Lake.</p> <p>Relative importance of study area: Although vulnerable in Victoria, the study area probably accounts for less than 10% of Victorian records and the species is widespread and at least relatively common outside the study area in Victoria and Australia.</p>
<p>Freckled Duck <i>Stictonetta naevosa</i> (e, l)</p>	<p>Sites mapped:</p> <ol style="list-style-type: none"> 1. Breeding sites: all areas with one or more records of Lake Bed Herbland, Lignum Swamp, Lignum Shrubland Lignum Swampy Woodland and mosaics or complexes containing one or more of these in the Hattah–Kulkyne National Park, Murray–Kulkyne Park and Lakes Powell and Carpul Nature Conservation Reserve. 2. Non-breeding sites: all areas of Tall Marsh/Open Water Mosaic at Reedy Swamp, Water Body – natural or man made, Tall Marsh/Aquatic Herbland Mosaic and Floodplain Wetland Aggregate at Lake Moodemere, and Bare Rock/Ground as per annotated map at Kings Billabong. <p>Minimum flood frequency: as per EVCs; 1 in 2 for Bare Rock/Ground and Water Body. Habitat/Location: Choice of EVCs corresponds with breeding and non-breeding habitat (whichever applies) as described in Marchant and Higgins (1990), with emphasis on open water for non-breeding sites. Lakes Konardin, Mourmpall and Powell are three of only seven recorded breeding sites in Victoria and the Hattah Lakes more broadly are a major concentration of records in general. Records not resulting in mapped</p>

Table 3. (cont.)
Species and
conservation status

Location and flood requirements	
<p>polygons were either too old and imprecise (W of Robinvale), too haphazard for reliable interpretation (Lindsay Island, NW of Merbein, Yambuna, NW of Cobram), and/or in wetlands where habitat suitability is entirely artificial (NW of Cobram, Lake Mulwala, sewage farms).</p> <p>Relative importance of study area: study area sites (excluding sewage farms) probably contribute less than 10% of Victorian records and Victoria is largely a non-breeding staging area: on this basis, the breeding sites/areas could be highly important.</p>	
Sites mapped:	
1. Lake Walla Walla and in Hattah–Kulkyne National Park: all areas of Lake Bed Herbland and adjoining (within 200 metres) Intermittent Swampy Woodland and Lignum Shrubland.	Australasian Shoveler <i>Anas rhynchotis</i> (v)
2. Kings Billabong: areas of Bare Rock/Ground and adjoining (within 200 metres) Intermittent Swampy Woodland and Lignum Shrubland.	
3. Loch Garry: all areas of Billabong Wetland Aggregate and Rushy Riverine Swamp.	
4. Reedy Swamp: all areas of Tall Marsh/Open Water Mosaic.	
5. Lake Moodemere: Water Body – natural or manmade, Floodplain Wetland Aggregate, Tall Marsh/Aquatic Herbland Mosaic, and adjoining (within 200 metres) Drainage Line Complex.	
Minimum flood frequency: as per EVCs; 1 in 2 for Bare Rock/Ground and Water Body. Flood duration: as per EVCs; 6–12 months for Bare Rock/Ground and Water Body.	
Habitat/Location: Choice of EVCs corresponds with habitat as described by Emison <i>et al.</i> (1987), with dense bordering grassy/rushy areas included for breeding (up to 200 m as used Marchant and Higgins (1990)).	
Numerous scattered records along all floodplains except Kiewa (but sparse along much of the Murray) – only those on still water bodies discernible on the VFD included here, except the following sites where there is only one record each (inclusion not justified given the mobility of this species): Lake Cullulleraine, NW of Reedy Swamp, Germill Swamp, NW of Dugays Bridge, Tram Swamp (Barmah Forest) also excluded: the two records there are too imprecise. Hattah Lakes are a major site.	
Relative importance of study area: The study area sites (excluding sewage farms) probably accounts for less than 10% of Victorian records, and main reason for current conservation status is based on low total population in Victoria, small area of occupancy.	
Sites mapped:	
1. Lake Walla Walla, Lakes Hawthorn and Ranfurley, Hattah–Kulkyne National Park and Lakes Powell and Carpuil: all areas of Lake Bed Herbland.	Hardhead <i>Aythya australis</i> (v)
2. Merbein Common: all areas of Alluvial Plains Semi-arid Grassland and Bare Rock/Ground.	
3. Kings Billabong: areas of Bare Rock/Ground.	
4. Germill Swamp: Spike-sedge Wetland/Tall Marsh Mosaic.	
5. Reedy Swamp: Tall Marsh/Open Water Mosaic.	
6. Along the Ovens River just upstream (for 2 km) of the Hume Bypass: Floodplain Wetland Aggregate.	
Minimum flood frequency: as per EVCs; 1 in 2 for Bare Rock/Ground. Flood duration: as per EVCs; 6–12 months for Bare Rock/Ground.	

Table 3. (cont.)
Species and
conservation status

Location and flood requirements	
<p>Habitat/Location: Only sites with three or more records (except sewage farms which are excluded – note that all three breeding records in the study area are in sewage farms) – there are in the order of 20 sites in the study area with fewer than three records. EVCs reflect habitat descriptions used in Marchant and Higgins (1990) and Emison <i>et al.</i> (1987): (large) deep, open (~permanent) wetlands, especially with abundant aquatic vegetation.</p> <p>Relative importance of study area: The study area sites (excluding sewage farms) probably account for less than 10% of Victorian records, and main reason for current conservation status is based on low total population in Victoria, small area of occupancy and habitat degradation. Note that concentrations of more than 50 000 and around 5 000 birds have been recorded not far from the study area on the Kerang Lakes and Moira Lakes (NSW) respectively.</p>	
<p>Sites mapped: <i>Breeding sites:</i> All areas of all flood-dependent EVCs within 1 km of breeding records, except at and around Lake Bitterang and Lake Hattah where mapped sites cover full extent of Intermittent Swampy Woodland and Lake Bed Hermland at those lakes. <i>Non-breeding sites:</i></p> <ol style="list-style-type: none"> <li data-bbox="283 355 305 1541">1. Lakes Ranfurley and Hawthorn (between Mildura and Merbein) and Hattah–Kulkyn National Park: all areas of Lake Bed Hermland. <li data-bbox="305 355 328 1541">2. Kings Billabong: areas of Bare Rock/Ground, and Lignum Swamp, Lignum Shrubland and Floodway Pond Hermland. <li data-bbox="328 355 350 1541">3. Owens River downstream of the former Regional Park/State Forest boundary: all areas of Water Body – natural or manmade, Floodplain Wetland Aggregate, Floodplain Riparian Woodland/Riverine Swamp Forest Mosaic and Riverine Swampy Woodland. <p>Minimum flood frequency: <i>Breeding sites:</i> as per EVCs; <i>Non-breeding sites:</i> as per EVCs; 1 in 2 for Water Body and Bare Rock/Ground. Flood duration: <i>Breeding sites:</i> 5 months; <i>Non-breeding sites:</i> as per EVCs; 6 – 12 months for Water Body and Bare Rock/Ground.</p> <p>Habitat/Location: Breeding sites mapped here are only those where nesting has actually been recorded (as opposed to extrapolating to cover all apparently suitable habitat). Pied Cormorants do not require trees to be inundated at time of nesting (hence minimum flood frequency and duration both as per EVCs unlike restricted obligate colonial breeders below). Non-breeding sites mapped if there were 8 or more records.</p> <p>Relative importance of study area: The six study area nesting sites are part of a total of around 50 in the VFD (but less than 10 of these are regular, recent or colonial sites – there would be value in systematically reviewing the breeding records and status of this species in Victoria), and the species is ‘only’ near threatened.</p>	<p>Pied Cormorant <i>Phalacrocorax varius</i> (n)</p>

Table 3. (cont.)
Species and
conservation status

Location and flood requirements

Little Egret
Egretta garzetta (e, L)

Sites mapped:

Breeding sites: All DSE wetland polygons and other points with breeding records and a surrounding 2 km buffer (for both).

Non-breeding sites:

1. Lakes Ranfurly and Hawthorn: all areas of Lake Bed Herbland.
2. Lakes Hattah, Little Hattah, Lockie, Yerang, Mourmpall, Bulla and Arawak: all areas of Lake Bed Herbland.
3. Ovens River c. 1.5 km E of Hume Highway (Wangaratta Bypass): all areas of Floodplain Riparian Woodland and Floodplain Wetland Aggregate within 1 km of record site.
4. Ovens River c. 4 km E of Hume Highway (Wangaratta Bypass): all areas of Floodplain Riparian Woodland, Floodplain Wetland Aggregate and Water Body — natural or manmade within 1 km of record site.
5. Ovens River SE of Whorouly: all areas of Swampy Woodland, Drainage Line Aggregate, Floodplain Wetland Aggregate and Water Body — natural or manmade within 1 km of record site.

Minimum flood frequency: *Breeding sites:* 1 in 5; *Non-breeding sites:* 1 in 2 for Water Body.

Flood duration: *Breeding sites:* 5 months; *Non-breeding sites:* as per EVCs, 6–12 months for Water Body.

Habitat/Location: All post-1960 breeding records in VFD and literature selected and mapped. Non-breeding records are sites with two or more post-1970 records.

Relative importance of study area: High — the study area nesting sites are the largest in Victoria (there are few in Victoria outside the study area) albeit not recent (2010 breeding in Barmah Forest is not included in this analysis) and the species is endangered.

Eastern Great Egret
Ardea modesta (v, L)

Sites mapped:

Breeding sites only: all DSE wetland polygons and other points with breeding records and a surrounding 2 km buffer (for both).

Minimum flood frequency: 1 in 5. **Flood duration:** 5 months.

Habitat/Location: Non-breeding records are too numerous, widely dispersed and of insufficient habitat specificity to warrant or allow singling out.

Intermediate Egret
Ardea intermedia (cc, L)

Sites mapped:

Breeding sites: All DSE wetland polygons and other points with breeding records and a surrounding 2 km buffer (for both).

Non-breeding sites:

1. Merbein Common: all areas of Alluvial Plains Semi-arid Grassland, Floodway Pond Herbland and Bare Rock/Ground — including the bend of the river NW of the main block.
2. Hattah Lakes: all areas of Lake Bed Herbland at Lakes Konardin, Yelwell, Mourmpall, Lockie, Hattah, Brockie and Nip Nip.
3. Guttram Forest: the areas of Floodway Pond Herbland/Riverine Swamp Forest Complex and Tall Marsh at 'Reed Bed' (the record site near the southern end of the forest).
4. Gunbower Creek at Wee Wee Rup (upstream of Cohuna): all areas of Water Body — natural or man made within 2 km of records.

Table 3. (cont.)
Species and
conservation status

Species and conservation status	Location and flood requirements
Nankeen Night-Heron <i>Nycticorax caldonicus</i> (n)	<p>5. Echuca: the area of Tall Marsh at/near record site.</p> <p>6. Barmah forest: all areas of Floodplain Grassy Wetland, Aquatic Hermland, Water Body – fresh and Spike sedge Wetland.</p> <p>7. Owens River c. 1.5 km E of Hume Highway (Wangaratta Bypass): all areas of Floodplain Riparian Woodland and Floodplain Wetland Aggregate within 1 km of record site.</p> <p>8. Brookfield (S of Everton): all areas of Billabong Wetland Aggregate, Drainage Line Aggregate, Floodplain Wetland Aggregate and Water Body – natural or man made within 1 km of record site</p> <p>9. Mt Ochertyre (S of Howlong): all areas of Floodplain Wetland Aggregate and Billabong Wetland Aggregate</p> <p>10. Ryans Lagoon (E of Wodonga): all areas of Drainage Line Aggregate, Floodplain Wetland Aggregate and Billabong Wetland Aggregate.</p> <p>Minimum flood frequency: <i>Breeding sites:</i> 1 in 5; <i>Non-breeding sites:</i> as per EVCs; 1 in 2 for Bare Rock/Ground and Water Body. Flood duration: <i>Breeding sites:</i> 5 months; <i>Non-breeding sites:</i> as per EVCs, 6-12 months for Bare Rock/Ground and Water Body.</p> <p>Habitat/Location: All post-1960 breeding records in VFD and literature have been selected and mapped (six sites in total, including three in Gunbower Forest). Note 2010 breeding in Barmah Forest not included in this analysis. Non-breeding records are sites with two or more post-1970 records.</p> <p>Relative importance of study area: Very high – the study area nesting sites are the only ones in Victoria and the species is critically endangered in Victoria.</p>
Australian Little Bittern <i>Isobrychus dubius</i> (e, l)	<p>Sites mapped: Breeding sites only: all DSE wetland polygons and other points with breeding records and a surrounding 2 km buffer (for both).</p> <p>Minimum flood frequency: 1 in 5. Flood duration: 5 months.</p> <p>Habitat/Location: Non-breeding records are too numerous, widely dispersed and of insufficient habitat specificity to warrant or allow singling out.</p> <p>Sites mapped: All areas of Tall Marsh and mosaics or complexes containing it upstream of Guttram Forest inclusive, and all areas of Intermittent Swampy Woodland within 2 km of the records at Hattah Lakes.</p> <p>Minimum flood frequency: as per EVCs. Flood duration: as per EVCs.</p> <p>Habitat/Location: Tall Marsh EVC (i.e. including <i>Typha</i> swamps) is the primary habitat in region based on expert knowledge and records. Intermittent Swampy Woodland is only conceivable habitat at Hattah Lakes. Note that some records (e.g. on Gunbower Creek about 1 km NNW of Cohuna) have little if any of this habitat; a recent record in Deniliquin where much of the <i>Typha</i> was under a River Red Gum canopy. Note that there are a few recent precise records (e.g. N of Moyhu on the King River) not close to any Tall Marsh – given the tendency of this species to inhabit artificial wetlands (often entirely artificial, and small), such sites have not been mapped here – they would be numerous but could be done in a more comprehensive analysis in the future. In</p>

Table 3. (cont.)
Species and
conservation status

Location and flood requirements

contrast, there are relatively large areas of Tall Marsh mapped for this species where there are no recent precise records (e.g. between Barmah Forest and Moyhu, Wodonga and Murchison, although Loyn *et al.* 2002 found them at Top Island of Barmah Forest) – but old, imprecise and nearby (outside study area) records indicate that they are likely to occur in at least parts of these areas.

Relative importance of study area: Although endangered in Victoria, the study area contributes only about 25% of Victorian records (many records are in the nearby Kerang and Corop Lakes) and the species is widespread, albeit uncommon, scattered and declining elsewhere in Australia.

Sites mapped:

All areas of Tall Marsh and mosaics or complexes with this EVC upstream of Swan Hill, and Intermittent Swampy Woodland at Lake Yerang (Hattah–Kulkyne National Park) and Aquatic Herbland, Freshwater Grassy Meadow and Water Body in Barmah Forest.

Minimum flood frequency: as per EVCs. **Flood duration:** as per EVCs.

Habitat/Location: Tall Marsh EVC, including *Phragmites* swamps, is the primary habitat in the region based on expert knowledge and records. Intermittent Swampy Woodland is only conceivable habitat at Hattah Lakes. Note that some records have little if any of this habitat and have been discounted given this species' tendency to sometimes inhabit artificial habitats such as rice fields and densely vegetated margins of channels (that is, the records may be from such habitats not dependent on floodplain inundation).

Relative importance of study area: Endangered in Victoria, and due to relatively recent rapid declines, recently listed as Endangered nationally. While the study area contributes about 25% of Victorian records (many records are in the nearby Kerang and Corop Lakes) it is likely to be very important breeding habitat for the species when flooded.

Sites mapped:

1. Lake Walla Walla and Hattah Lakes: all areas of Lake Bed Herbland.
2. Gumbower Forest: all areas of Spike-sedge Wetland and Floodway Pond Herbland/Riverine Swamp Forest Complex.
3. Loch Garry: all areas of Billabong Wetland Aggregate and Rushy Riverine Swamp.
4. Reedy Swamp: all areas of Tall Marsh/Open Water Mosaic.
5. Barmah Forest: all areas of Floodplain Grassy Wetland, Aquatic Herbland/Tall Marsh Mosaic, Floodplain Grassy Wetland/Riverine Swamp Forest Mosaic, Aquatic Herbland/Floodplain Grassy Wetland Mosaic, and Aquatic Herbland.
6. Ovens River downstream of the former Regional Park/State Forest boundary: all areas of Water Body – natural or man made, Floodplain Wetland Aggregate, and Floodplain Riparian Woodland/Riverine Swamp Forest Mosaic.
7. Ryans Lagoon (E of Wodonga): all areas of Drainage Line Aggregate, Floodplain Wetland Aggregate and Billabong Wetland Aggregate.

Minimum flood frequency: as per EVCs. **Flood duration:** as per EVCs.

Habitat/Location: No breeding records in the study area (but several in the Kerang Lakes and Marchant and Higgins (1990)). Use of non-breeding areas based on there being only 63 records in the River Red Gum Forests. Investigation area (mostly in the Kerang Lakes).

Australasian Bittern
Botaurus poiciloptilus (E, e, I)

Glossy Ibis
Plegadis falcinellus (n)

Table 3. (cont.)
Species and
conservation status

Royal Spoonbill <i>Platalea regia</i> (v)	<p>Location and flood requirements</p> <p>Relative importance of study area: This species is only near threatened in Victoria.</p> <p>Sites mapped: <i>Breeding sites:</i> All DSE wetland polygons and other points with breeding records and the surrounding 2 km (for both). <i>Non-breeding sites:</i></p> <ol style="list-style-type: none"> 1. Lake Walla Walla and Hattah Lakes: all areas of Lake Bed Herbland. 2. Gunbower Forest: all areas of Spike-sedge Wetland and Floodway Pond Herbland/Riverine Swamp Forest complex. 3. Loch Garry: all areas of Billabong Wetland Aggregate and Rushy Riverine Swamp. 4. Reedy Swamp: all areas of Tall Marsh/Open Water Mosaic. 5. Barmah Forest: all areas of Floodplain Grassy Wetland, Aquatic Herbland/Tall Marsh Mosaic, Floodplain Grassy Wetland/Riverine Swamp Forest Mosaic, Aquatic Herbland/Floodplain Grassy Wetland Mosaic, and Aquatic Herbland. 6. Ovens River downstream of the former Regional Park/State Forest boundary: all areas of Water Body – natural or man made, Floodplain Wetland Aggregate, and Floodplain Riparian Woodland/Riverine Swamp Forest Mosaic. 7. Ryans Lagoon (E of Wodonga): all areas of Drainage Line Aggregate, Floodplain Wetland Aggregate and Billabong Wetland Aggregate. <p>Minimum flood frequency: <i>Breeding sites:</i> 1 in 5; <i>Non-breeding sites:</i> as per EVCs. Flood duration: <i>Breeding sites:</i> 5 months; <i>Non-breeding sites:</i> as per EVCs.</p> <p>Habitat/Location: All post-1960 breeding records in VFD and literature selected and mapped. Non-breeding records are sites with three or more post-1970 records.</p> <p>Relative importance of study area: Moderate – the study area nesting sites are among the largest in Victoria but there are several other sites in Victoria outside the study area; the species is vulnerable.</p>
White-bellied Sea-Eagle <i>Haliaeetus leucogaster</i> (v, L)	<p>Sites mapped:</p> <ol style="list-style-type: none"> 1. Lake Walla Walla, Hattah –Kulkyne National Park and Lakes Powell and Carpul: all areas of Lake Bed Herbland. 2. Kings Billabong: areas of Bare Rock/Ground, and Lignum Swamp, Lignum Shrubland and Floodway Pond Herbland. 3. Baillieu Lagoon: all areas of Spike-sedge Wetland. 4. Loch Garry: all areas of Billabong Wetland Aggregate. 5. Reedy Swamp: all areas of Tall Marsh/Open Water Mosaic. 6. Barmah Lake, Doctors/Keys and Tongalong Creek: all areas of Water Body – natural or man made. 7. Ovens River downstream of the Murray Valley Highway: all areas of Water Body – natural or man made, Floodplain Wetland Aggregate, Floodplain Riparian Woodland/Riverine Swamp Forest Mosaic and Riverine Swampy Woodland.

Table 3. (cont.)
Species and
conservation status

Location and flood requirements	
8. Lake Moodemere: Water Body – natural or man made, Floodplain Wetland Aggregate, Tall Marsh/Aquatic Herland Mosaic and Drainage Line Complex.	Red-chedsted Button-quail <i>Turnix pyrrhithorax</i> (v, L)
Minimum flood frequency: as per EVCs; 1 in 2 for Bare Rock/Ground and Water Body. Flood duration: as per EVCs, 6-12 months for Bare Rock/Ground and Water Body.	
Habitat/Location: Sites with two or more post-1970 records.	
Relative importance of study area: High to moderate – the study area supports a very large proportion of the inland population of this vulnerable species.	
Sites mapped:	
Riverine Swamp Forest around Gunbower and Guttrum forest records. Intermittent Swampy Woodland around Lindsay Island record, while White Cliffs record in drainage line not mapped as a distinct EVC.	
Minimum flood frequency: as per EVCs. Flood duration: as per EVCs.	
Habitat/Location: Conole and Mac Nally (2001) state that records of this species in Gunbower forest are in 'areas of bare ground and abundant leaf litter, little or no understorey and patches of tussock grass or sedges'. The records in Gunbower equate to Riverine Swamp Forest EVC.	
Relative importance of study area: Considered vulnerable and listed on the FFG, it is suggested that this species may be more numerous in riverine forests than first thought (Conole and Mac Nally 2001); however, no subsequent records in this habitat are known.	
Sites mapped:	
All polygons of Floodplain Grassy Wetland and mosaics or complexes containing it in Barmah forest.	Brolga <i>Grus rubicunda</i> (v, L)
Minimum flood frequency: as per EVCs. Flood duration: as per EVCs.	
Habitat/Location: Expert opinion of former habitat and occurrence; note there are many VFD and Birdata records close to the study area, but few if any actually within it since 1970.	
Relative importance of study area: although vulnerable in Victoria, there are now no regular sites in the study area (although there have been recent 2010 breeding records in Barmah Forest for the first time in many years); Victorian stronghold is shallow wetlands on the central northern plains immediately south of the study area and in south-west Victoria, and is numerous in at least parts of its extensive distribution outside study area in Australia. A distinctive feature of the approach for this species is the objective is entirely recovery, as opposed to (at least partly) maintaining existing populations. This recovery will require habitat to be reinstated, which has not been explicitly addressed in specifying areas and flood frequency and duration here – further work is required to properly specify requirements for recovery.	
Sites mapped:	
Areas of wetland EVCs at Baillieu Lagoon where there are known records not in VFD and around VFD records at Kings Billabong.	Baillon's Crane <i>Porzana pusilla</i> (v, L)
Minimum flood frequency: as per EVCs. Flood duration: as per EVCs.	
Habitat/Location: based on VFD records at Kings Billabong and unpublished records at Baillieu Lagoon.	
Relative importance of study area: Despite being vulnerable in Victoria, there are few records in the study area and much of the Victorian range is to the south.	

Table 3. (cont.)
Species and
conservation status

	Location and flood requirements
Latham's Snipe <i>Gallinago hardwickii</i> (n)	<p>Sites mapped: Wetland EVCs around VFD records and a polygon of Riverine Chenopod Woodland south of Beveridge Island.</p> <p>Minimum flood frequency: as per EVCs. Flood duration: as per EVCs.</p> <p>Habitat/Location: This species prefers open, shallow wetlands and grasslands. Records based on those in VFD and Birddata.</p> <p>Relative importance of study area: Much of the Victorian range is to the south. Considered near threatened in Victoria.</p>
Australian Painted Snipe <i>Rostratula australis</i> (V, ce, L)	<p>Sites mapped: Wetlands around Lake Hattah and at Lake Yerang.</p> <p>Minimum flood frequency: as per EVCs. Flood duration: as per EVCs.</p> <p>Habitat/Location: Inhabits shallow, vegetated, temporary or infrequently filled wetlands, sometimes where there are shrubs such as lignum or samphire. Poorly known species due to its secretive nature. Records from VFD and Birdata and experts. Possibly occurs more regularly than records suggest, particularly due to their known occurrence in parts of the Kerang Lakes.</p> <p>Relative importance of study area: Few records in the study area, with more in Kerang Lakes area to the south. Listed as nationally vulnerable, considered critically endangered in Victoria (and listed on the FFG Act).</p>
Bush Stone-curlew <i>Burhinus grallarius</i> (e, L)	<p>Sites mapped: Nearest Riverine Chenopod Woodland areas to records at Lindsay Island, Wallpolla Island, Hattah–Kulkyne National Park and Kanyapella Basin.</p> <p>Minimum flood frequency: as per EVCs. Flood duration: as per EVCs.</p> <p>Habitat/Location: EVC from expert opinion understanding of habitat and occurrence, namely Riverine Chenopod Woodland EVC. In the southern section of study area found within Plains Woodland vegetation adjoining floodplain (e.g. Wyuna) which is not flood-dependent with the exception of Kanyapella Basin. In NW (Hattah, Wallpolla Island Lindsay Island) — records from floodplain vegetation. That is, only sites at Kanyapella and in the NW are included here.</p> <p>Relative importance of study area: Although considered endangered in Victoria and listed on the FFG, floodplain vegetation does not represent suitable habitat for most of the species range in Victoria. However, it does represent important habitat in NW Victoria and into SA along the Murray River (see also Gates and Paton 2005).</p>
Gull-billed Tern <i>Gelocheidon nilotica</i> (e, L)	<p>Sites mapped:</p> <ol style="list-style-type: none"> <li data-bbox="880 110 918 1387">1. Lake Bed Herbland at Lake Mournpall (north of Lake Hattah) and Lakes Hawthorn and Ranfurley (between Mildura and Merbein). <li data-bbox="924 110 993 1387">2. The Riverine Chenopod Woodland polygon at Lake Culluleraine — which is actually open water. <p>Minimum flood frequency: as per EVCs, 1 in 2 for Lake Culluleraine. Flood duration: as per EVCs, 6-12 months for Lake Culluleraine.</p>

Table 3. (cont.)
Species and
conservation status

Species and conservation status	Location and flood requirements
Caspian Tern <i>Hydroprogne caspia</i> (n, L)	<p>Habitat/Location: There are potential difficulties identifying areas for this species given the birds' propensity to be seen flying (and sometimes appearing to be foraging) over a variety of open habitats, wet or dry (Higgins and Davies 1996). However, there are only 11 records in the study area (none breeding) — in the open-water polygons identified here and at three sites along the Murray River for which no areas are identified here (the records are old, imprecise, may relate to birds in transit and/or the upshot for this species would be just to have water in the river): just upstream of Loch 7 (2 records), Red Cliffs (1) and near Barham (3).</p> <p>Relative importance of study area: Although endangered in Victoria, the study area contributes only about 10% of Victorian records (although there are many records in the nearby Kerang Lakes). More pertinent, perhaps, the main reason for its conservation status is that it is a restricted colonial breeder and there are no breeding records in the study area. Extensive distribution and at least reasonably common elsewhere in Australia and the world (based on current taxonomy).</p> <p>Sites mapped:</p> <ol style="list-style-type: none"> Lake Bed Herbland at Lake Walla Walla, Lake Mournpall (north of Lake Hattah) and Lakes Hawthorn and Ranfurley (between Mildura and Merbein). Bare Rock/Ground at Kings Billabong. <p>Minimum flood frequency: as per EVCs; 1 in 2 for Bare Rock/Ground. Flood duration: as per EVCs, 6-12 months for Bare Rock/Ground.</p> <p>Habitat/Location: Only sites with four or more records (except Mildura sewage farm records at Chaffey's Bend generally are taken as from the sewage farm or river — little if any other suitable habitat appears to exist in this area; note that there is a breeding record just outside the study area at Koorlong, south of Mildura Airport). Open water EVCs reflect habitat descriptions of Higgins and Davies (1996) and Emison <i>et al.</i> (1987).</p> <p>Relative importance of study area: Only near threatened and only because it is a restricted (semi-colonial) breeder with no breeding records in the study area. The study area contributes only about 20% of Victorian records — the species has an extensive distribution and is at least reasonably common outside study area in Victoria, Australia and the world.</p>
Whiskered Tern <i>Chlidonias hybrida</i> (n)	<p>Sites mapped: The main areas(s) of Floodplain Grassy Wetland at Steamer Plain (Barmah Forest).</p> <p>Minimum flood frequency: as per EVCs. Flood duration: as per EVCs.</p> <p>Habitat/Location: There are only three breeding records (although several more in recent years), all in Barmah Forest (1964, 1968, 1979 — the last of which is the basis of the area(s) delineated and is the same site as the 1964 record). Non-breeding records are too numerous, widely dispersed and of insufficient habitat specificity to warrant or allow singling out.</p>
Diamond Dove <i>Geopelia cuneata</i> (n, L)	<p>Sites mapped: Riverine Chenopod Woodland or Riverine Grassy Woodland (and or complexes/mosaics) around records.</p> <p>Minimum flood frequency: as per EVCs. Flood duration: as per EVCs.</p>

Table 3. (cont.)
Species and
conservation status

Species and conservation status	Location and flood requirements
Superb Parrot <i>Polytelis swainsonii</i> (V, e, L)	<p>Habitat/Location: Emison <i>et al.</i> (1987) state that Diamond Doves occur in River Red Gum forests and woodlands in the mid and upper Murray Valley. In NSW they are also observed in sandhill and <i>Callitris</i> dominated areas but this does not necessarily equate with EVCs from Victorian records. VED records and Birdata records are mostly around areas of Riverine Chenopod Woodland or Riverine Grassy Woodland EVCs.</p> <p>Relative importance of study area: A reasonable proportion of the Victorian distribution is within study area. PFG listed and near threatened.</p> <p>Sites mapped: Breeding sites from detailed maps prepared by experts (details confidential).</p> <p>Minimum flood frequency: 1 in 3 yrs. Flood duration: 1 month.</p> <p>Habitat/Location: Breeding sites in Barham Forest well mapped as part of recovery actions for this species. Water requirements of nest sites based on discussions with experts.</p> <p>Relative importance of study area: High because study area contains all current Victorian breeding sites (which are flood-dependent) of this species, which is endangered in the state and vulnerable nationally.</p>
Regent Parrot <i>Polytelis anthopeplus monarchoides</i> (V, v, L)	<p>Sites mapped: Breeding sites from detailed maps prepared by experts (details confidential).</p> <p>Minimum flood frequency: 1 in 5-7 yrs. Flood duration: 1 month.</p> <p>Habitat/Location: Breeding sites mapped by Rick Webster based on site visits. Water requirements of nest sites follow discussions with experts. Breeding birds regularly fly along treed floodplain between breeding sites and feeding and non-breeding areas — it may be possible to map these with further investigation but not done here.</p> <p>Relative importance of study area: High because study area contains most current Victorian breeding sites (which are flood-dependent) of this vulnerable subspecies.</p>
Black-chinned Honeyeater <i>Meliphreptus gularis</i> (n)	<p>Sites mapped: All areas of Riverine Swamp Forest and mosaics or complexes around VED and Birdata records upstream of Gunbower Forest inclusive.</p> <p>Minimum flood frequency: as per EVCs. Flood duration: as per EVCs.</p> <p>Habitat/Location: EVCs from expert opinion understanding of habitat and occurrence; all records downstream of Gunbower Forest are old, imprecise and/or outside study area, and too remote to extend the distribution this far.</p> <p>Relative importance of study area: 'Only' near threatened; extensive distribution outside study area in Victoria and Australia — stronghold is drier forests and woodlands, notably Box-Ironbark.</p>
Painted Honeyeater <i>Granitella picta</i> (v, L)	<p>Sites mapped: All areas of Riverine Chenopod Woodland and Riverine Grassy Woodland and mosaics or complexes containing one or more of these EVCs within 5 km of all selected record sites.</p> <p>Minimum flood frequency: as per EVCs. Flood duration: as per EVCs.</p> <p>Habitat/Location: EVCs from expert opinion understanding of habitat and occurrence; note Birdata record near Wodonga.</p>

Table 3. (cont.)
Species and
conservation status

Location and flood requirements

Relative importance of study area: Although vulnerable in Victoria, there are few if any regular sites in the study area, Victorian stronghold is drier woodlands (notably Box-Ironbark forests and woodlands) and is numerous in at least parts of its extensive distribution outside study area in Australia.

Hooded Robin
Melanodryas cucullata (n, L)

Sites mapped:

All areas of Riverine Chenopod Woodland and Riverine Grassy Woodland and mosaics or complexes containing one or more of these. All Riverine Chenopod Woodland in northern lobe of Kings Billabong. The Lindsay Island record is within Semi-arid Chenopod Woodland, the record in northern Hattah-Kulkyne National Park is Riverine Grassy Forest and the area south of Gadsden Bend is Lignum Swampy Woodland.

Minimum flood frequency: as per EVCs. **Flood duration:** as per EVCs.

Habitat/Location: EVCs from experts' understanding of habitat and occurrence. Sandy rises, Black Box and River Red Gum that is less likely to be flooded are the main habitats in the study area. Requires fallen timber and no reeds or sedges.

Relative importance of study area: Although near threatened in Victoria, and listed on the FFG, the study area represents only a small proportion of Victoria's population.

Grey-crowned Babbler
Pomatostomus temporalis (e, L)

Sites mapped:

All areas of the following EVCs where they intersect with records:

1. For the Nyah-Vinifera area, the following EVCs are relevant: Grassy Riverine Forest, Sedgy Riverine Forest/Riverine Swamp Forest Complex, Sedgy Riverine Forest, Riverine Swamp Forest.
2. In the stretch between Tocumwal to Echuca, key EVCs are Grassy Riverine Forest, Riverine Grassy Woodland and Riverine Swamp Forest.
3. For the Gunbower area: Riverine Grassy Woodland, Riverine Swamp Forest and Grassy Riverine Forest are relevant.
4. At Lake Carnul: Lignum Swamp Woodland.

Minimum flood frequency: as per EVCs. **Flood duration:** as per EVCs.

Habitat/Location: EVCs based on expert opinion understanding of habitat and occurrence and informed by VFD and Birdata records. Occurs mostly on edges of floodplain country, often in Black Box. More common on the Loddon floodplain (outside of study area).

Relative importance of study area: Although considered endangered in Victoria, and listed on the FFG, the study area represents only a small proportion of Victoria's population.

Apostlebird
Struthidea cinerea (L)

Sites mapped:

All areas of Riverine Chenopod Woodland and Riverine Grassy Woodland and mosaics or complexes containing one or more of these downstream of Narrung State Forest inclusive.

Minimum flood frequency: as per EVCs. **Flood duration:** as per EVCs.

Habitat/Location: EVCs chosen based on expert opinion of habitat and occurrence; former Narrung State Forest to encompass January 1978 record in VFD (Rick Webster has recorded them between Yungera and Boundary Bend in recent years – not in VFD) – all records upstream of here are old, imprecise

Table 3. (cont.)
Species and
conservation status

Location and flood requirements

and/or outside study area, except one from just SE of Koondrook 24/12/99 which not mapped here (if there was a group still resident there it would be well-known); Emison *et al.* (1987): 'Black Box woodlands along the floodplain.'
Relative importance of study area: Although much of this species' Victorian distribution is within the study area (but not the population in NE Victoria) it is 'only' FFG-listed (not on the DSE 2007 Advisory List), and is abundant in southern New South Wales. Note, though, that it has declined significantly in Victoria (and South Australia) but also earlier in the 20th century has expanded significantly in some areas (NSW mostly; Higgins *et al.* 2006).

Diamond Firetail
Stagonopleura guttata (v, L)

Sites mapped:
Riverine Chenopod Woodland or Riverine Grassy Woodland (and or complexes/mosaics) around records.
Minimum flood frequency: as per EVCs. **Flood duration:** as per EVCs.
Habitat/Location: EVC determinations from expert opinion. Distribution based on VFD records but also includes Birdata records where not in VFD. A fauna survey at Macreadie Island and Burra Forest found a total

of 11 birds at six of the survey sites which included the EVCs Grassy Riverine Forest, Lignum Swampy Woodland, Riverine Chenopod Woodland, Riverine Grassy Woodland (Lumsden *et al.* 2007). Also occurs in Plains Woodland (e.g. in Gunbower Forest) but this EVC is not flood-dependent. Also recorded in Black Box woodland with Lignum understorey near Swan Hill.

Relative importance of study area: Reasonably widespread. Not threatened nationally but FFG-listed in Victoria and vulnerable both there and in NSW. The study area accounts for <20% of Victorian records.

Giles' Planigale
Planigale gilesi (n, L)

Sites mapped:
All areas of Lignum Swampy Woodland and Riverine Chenopod Woodland and mosaics or complexes containing one or more of these EVCs around records.

Minimum flood frequency: as per EVCs. **Flood duration:** as per EVCs.

Habitat/Location: EVCs based on FFG Action Statement which states: 'Within Victoria, it has been recorded only on alluvial floodplains with grey cracking soils, in or near Black Box (*Eucalyptus largiflorens*) woodlands with a patchy, but dense, understorey of Tangled Lignum (*Muehlenbeckia cunninghamii*), Nitre Goosefoot (*Chenopodium nitriaceum*) or Old-man Salibush (*Atriplex nummularia*)' (Bennett and Lumsden 1994). This equates to Lignum Swampy Woodland and Riverine Chenopod Woodland. Sites delineated where VFD records the two records of Woolley (2004) intersect with these EVCs.

Relative importance of study area: Only relatively recently discovered in Victoria (Lumsden *et al.* 1988) and entirely restricted to the study area. Considered near threatened in Victoria and FFG-listed. Widespread north of Victoria in the Lake Eyre Drainage Basin and the western half of the Murray-Darling Basin.

Squirrel Glider
Petaurus norfolcensis (e, L)

Sites mapped:
All polygons of Floodplain Riparian Woodland and mosaics or complexes containing it upstream of Brereton Rd in Gunbower Forest (including along tributaries to end of study area).
Minimum flood frequency: as per EVCs. **Flood duration:** as per EVCs.

Table 3. (cont.)
Species and
conservation status

Location and flood requirements

Habitat/Location: EVC from expert opinion understanding of habitat and occurrence (reasonable-sized healthy stands of *Acacia dealbata* being the key requirement); distribution based on VFD; Rick Webster has records close to the Murray River in NSW about 10 km downstream of Echuca; Brereton Rd is selected as the boundary because it is the first clear boundary heading downstream from the most downstream record.
Relative importance of study area: Reasonably widespread and not threatened nationally, but endangered in Victoria where the study area probably accounts for about 20% of records — would be highly important if proportion of Victorian population was higher.

Southern Myotis
Myotis macropus (n)

Sites mapped:
Floodplain Riparian Woodland along the Ovens and Goulburn Rivers that are within 1 km of record plus Lagoon Wetland and Floodplain Wetland Complex that are within 1 km of records. For Barmah Forest, include 'Water Bodies' EVC downstream of Barmah Bridge along the Murray for 1 km and all 'Water Bodies' EVC along Murray River upstream of Barmah Bridge to Barmah Lake inclusive.
Minimum flood frequency: as per EVCs. **Flood duration:** as per EVCs.
Habitat/Location: EVC derived from associations with requirement for water (i.e. EVCs surrounding a watercourse or billabong) with advice from experts. Barmah Forest EVCs determined from findings of Law and Anderson (1999) of records of the species on the Murray River at Barmah Bridge (Moira Lake), and an unpublished record between these sites. Barmah Lake included as they were recorded on Moira Lake. Note Law and Anderson's (1999) comment about difficulties in detectability over large waterbodies (which may possibly explain lack of records from Loyn *et al.* 2002).
Relative importance of study area: Limited range in northern Victoria and southern NSW.

Broad-shelled Turtle
Macrochelodina expansa (e, L)

Sites mapped:
Watercourse and billabong EVCs around records.
Minimum flood frequency: as per EVCs. **Flood duration:** as per EVCs.
Habitat/Location: Requires open water, be it part of a river channel or billabong.
Relative importance of study area: Although considered endangered in Victoria and listed on the FFG, it is likely to occur along the entire stretch of the Murray and associated creeks and billabongs. Flooding would provide further habitat in ephemeral billabongs (e.g. Meathrel *et al.* 2002, 2004).

Murray River Turtle
Emydura macquarii (d, L)

Sites mapped:
Watercourse and billabong EVCs around records.
Minimum flood frequency: as per EVCs. **Flood duration:** as per EVCs.
Habitat/Location: Requires open water, be it part of a river channel or billabong.
Relative importance of study area: Considered depleted in Victoria and FFG-listed, it is likely to occur along the entire stretch of the Murray River and associated creeks and billabongs. Flooding would provide further habitat in ephemeral billabongs (e.g. Meathrel *et al.* 2002, 2004).

Table 3. (cont.)
Species and
conservation status

Species and conservation status	Location and flood requirements
Eastern Bearded Dragon <i>Pogona barbatus</i> (d)	<p>Sites mapped: Riverine Chenopod Woodland and Riverine Grassy Woodland around records.</p> <p>Minimum flood frequency: as per EVCs. Flood duration: as per EVCs.</p> <p>Habitat/Location: Expert opinion suggests this species is a woodland generalist. The riverine forests constitute a relatively small proportion of its habitat in Victoria but maintaining the health of these forests and woodlands is considered important for the species. EVC are Riverine Grassy Woodland and Riverine Chenopod Woodland (based on site records and advice from experts). Records from VFD plus Lumsden <i>et al.</i> (2007). The record of this species at Neds Corner (Malone 2004) is most likely erroneous and should be Central Bearded Dragon.</p> <p>Relative importance of study area: Considered data deficient in Victoria and limited range in study area.</p>
Tree Goanna <i>Varanus varius</i> (v)	<p>Sites mapped: Lindsay and Wallpolla Islands – all creeklines with Intermittent Swampy Woodland. In Gumbower, all records of Riverine Chenopod Woodland. In Hattah all areas of the following EVCs around the groups of records: Riverine Chenopod Woodland, Intermittent Swampy Woodland, Lignum Swampy Woodland and Riverine Grassy Woodland. At other localities Shrubby Riverine Forest or Intermittent Swampy Woodland (around Mildura) or Grassy Riverine Forest (Macreadie Island) areas surrounding records.</p> <p>Minimum flood frequency: as per EVCs. Flood duration: as per EVCs.</p> <p>Habitat/Location: In Gumbower Forest, records seem to be restricted to Black Box country (i.e. Riverine Chenopod Woodland). Around Hattah it is less clear cut and the distribution seems to intersect with Riverine Chenopod Woodland, Intermittent Swampy Woodland, Lignum Swampy Woodland and possibly Riverine Grassy Woodland. Intermittent Swampy Woodland occurs on the creeks connecting the Murray River with the lakes and around the lakes themselves. At Wallpolla and Lindsay Islands most records appear to be associated with the creeks which are Intermittent Swampy Woodland. Records to the east of Gumbower Forest in the study area are mostly associated with Plains Woodland (i.e. Grey Box). Records are from VFD and Lumsden <i>et al.</i> (2007).</p> <p>Relative importance of study area: Although vulnerable in Victoria, the species has a relatively wide range and is more common in other parts of the state.</p>
Eastern Water Skink <i>Eulamprus quoyii</i> (n)	<p>Sites mapped: Creeklime and/or billabong vegetation around records.</p> <p>Minimum flood frequency: as per EVCs. Flood duration: as per EVCs.</p> <p>Habitat/Location: Associated with freestanding water, including the Murray River. VFD records plus records from Malone (2004).</p> <p>Relative importance of study area: Near threatened in Victoria but locally abundant in the northwest. This part of Victoria is at the southern tip of its Australian distribution.</p>